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CALSPAN ON-SITE AMBULANCE CRASH INVESTIGATION

SCI CASE NO.: CA12034

VEHICLE: 2005 FORD ECONOLINE 350 / MCCOY MILLER TYPE III AMBULANCE

LOCATION: KENTUCKY

CRASH DATE: JULY 2012

Contract No. DTNH22-07-C-00043

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The crash investigation process is an inexact science which requires that physical evidence such as skid marks, vehicular damage measurements, and occupant contact points are coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.

Because each crash is a unique sequence of events, generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicle(s) or their safety systems.

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16. Abstract This on-site investigation focused on the crash circumstances and patient compartment of a 2005 Ford Econoline 350 / McCoy Miller Type III ambulance involved in a shallow angle configuration crash with a 1999 Jeep Cherokee. A 59-year-old male patient within the ambulance sustained fatal injuries in the crash. The ambulance was configured with a forward cab and a rear patient compartment equipped for the treatment of medical emergencies in a mobile environment. It was traveling south on a two-lane roadway and operating in a non-emergent mode (without the use of its warning lights or siren) while transporting the 59-year-old male patient to a local facility for dialysis. A 21-year-old male operated the Ford, while a 25-year-old Emergency Medical Services (EMS) crewmember provided patient care. As the Jeep traveled north on the same roadway, it began to cross over the roadway's centerline. The driver of the ambulance identified the northbound Jeep's errant trajectory and applied the brakes while steering right in an attempt to avoid a collision. However, the Jeep maintained its trajectory toward the ambulance and the two vehicles collided in a shallow angle configuration. During the crash sequence, the ambulance entered a rollover sequence and completed two-quarter turns before coming to final rest on its top plane. Ground ambulances transported the ambulance's male driver and patient to a local hospital, while the 25-year-old male EMS crewmember was airlifted to a regional trauma center. The 59-year-old male patient succumbed to his injuries within hours.			
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BACKGROUND

This on-site investigation focused on the crash circumstances and patient compartment of a 2005 Ford Econoline 350 (E350) / McCoy Miller Type III ambulance (**Figure 1**) involved in a shallow angle configuration crash with a 1999 Jeep Cherokee. A 59-year-old male patient within the ambulance sustained fatal injuries in the crash. The Calspan Special Crash Investigations (SCI) team identified the crash on July 25, 2012 and provided notification to the Crash Investigation Division (CID) of the National Highway Traffic Safety Administration (NHTSA). Due to NHTSA's Office of Emergency Medical Services (OEMS) interest in the crash, the CID assigned the crash for on-site investigation to the Calspan SCI team on Thursday, July 26, 2012. Calspan SCI immediately initiated contact with the investigating State Trooper, and cooperation was established on July 28, 2012 to perform an on-site inspection of the ambulance at impound on July 30-31, 2012. The on-site portion of this investigation consisted of the detailed inspection and documentation of the crash site and limited inspection of the involved vehicles due to restrictions imposed by the law enforcement agency. Specifically, the inspection of the Jeep was restricted to photographs only and no physical entry into the ambulance was permitted.

Figure 1: Involved ambulance at final rest *(image obtained from a local news source).*

The 2005 Ford/McCoy Miller Type III ambulance was traveling south on a two-lane roadway while transporting the 59-year-old male patient to a local facility for dialysis. It was operating in a non-emergent mode, without the use of its warning lights or siren. A 21-year-old male operated the Ford, while a 25-year-old Emergency Medical Services (EMS) crewmember provided patient care. The Jeep was traveling north on the same roadway and began to cross over the roadway's centerline. The driver of the ambulance saw the Jeep's movement and applied the brakes while steering right in an attempt to avoid a collision. This action was unsuccessful, as the Jeep maintained its trajectory toward the ambulance and the two vehicles collided in a shallow angle configuration. During the crash sequence, the ambulance entered a rollover sequence and completed two-quarter turns before coming to final rest on its top plane. Ground ambulances transported the ambulance's male driver and patient to a local hospital, while the 25-year-old male EMS crewmember was airlifted to a regional trauma center. The 59-year-old male patient succumbed to his injuries within hours.

CRASH SUMMARY

Crash Site

The crash occurred on a rural two-lane roadway during daylight hours. Weather conditions at the time of the crash were clear skies with a temperature of 26.7 Celsius (80 Fahrenheit) degrees, 9.3 km/h (5.8 mph) east-northeasterly breeze, and 79% relative humidity. The roadway surface was dry bituminous (asphalt). Both the northbound and southbound travel lanes were 3.1 m (10 ft) wide, supported by narrow 0.3 m (1 ft) shoulders with rumble strips. The travel lanes were delineated by a yellow centerline. Passing was permitted south of the point of impact for northbound traffic, but was not allowed in either direction north of the impact location. West of the roadway was a shallow ditch that transitioned into an embankment. For southbound traffic north of the impact location, in the ambulance's pre-crash travel direction, the roadway followed a gentle left curve and straightened out 40 m (131 ft) north of the point of impact (**Figure 2**). For the northbound traffic south of the impact point, in the Jeep's pre-crash travel direction, the roadway was straight and level (**Figure 3**). Speed was regulated by a posted limit of 89 km/h (55 mph). A Crash Diagram is included on page 19 of this technical report.

Figure 2: Southbound trajectory view of the ambulance's pre-crash travel path.

Figure 3: Northbound trajectory view of the Jeep's pre-crash travel path.

Pre-Crash

A request was received by a local emergency response system for an ambulance to transport a 59-year-old male to a local facility for dialysis. The subject 2005 Ford E350 Type III ambulance responded to the location of the request with a crew of two EMS workers, consisting of the 21-year-old male driver and the 25-year-old crewmember. After evaluating the individual, the crew moved the patient to the stretcher and secured him using the stretcher's multi-point harness system for manual restraint. They then wheeled the stretcher to the ambulance and loaded it into the patient compartment. The 25-year-old male, who was seated on the left-facing, three-passenger bench seat, did not utilize the available lap belt for manual restraint because he planned to assess the patient, obtain his vital signs, and complete associated documentation. The 21-year-old male utilized the available 3-point lap and shoulder safety belt system for manual restraint and operated the ambulance.

Due to the non-emergent nature of the transport, the ambulance was operated without the use of its emergency warning lights or siren. After traveling approximately 10 minutes over a distance of 10 km (6 mi), the ambulance was southbound on the two-lane roadway.

The Jeep traveled north on the same two-lane roadway. Minutes prior, reports were received by the local emergency response system regarding the Jeep's erratic and reckless driving. It was reported that the Jeep had departed an unrelated roadway, struck a mailbox and utility pole, and fled the scene. Local law enforcement personnel on patrol were attempting to locate and stop the Jeep in reference to these reports.

As the Jeep traveled north on the two-lane roadway and approached the southbound ambulance, it began to cross over the roadway's yellow centerline. The 21-year-old male driver of the ambulance reported seeing the northbound Jeep as it crossed the centerline into the ambulance's travel path. According to the ambulance driver, he applied the brakes and steered right in an attempt to avoid a collision. His statements were supported by the evidence at the scene (**Figure 4**), which revealed that the ambulance's right front tire departed the right roadway edge north of the point of impact. There was no evidence of any avoidance action by the driver of the Jeep.

Figure 4: Roadside departure evidence associated with the ambulance's travel path.

Crash

The first crash event occurred as the left aspect of the Jeep's frontal plane impacted the forward aspect of the Ford's left plane in a shallow angle configuration. Resultant directions of force were within the eleven o'clock sector for the ambulance and the twelve o'clock sector for the Jeep. As the left front axles of both vehicles engaged, the Ford's frontal air bag system deployed. The configuration of the Event 1 impact was evidenced by the impression of the Jeep's left side mirror on the ambulance's left front fender. As the vehicles crushed to maximum engagement, the left aspect of the Jeep's frontal plane and hood engaged the left front corner of the ambulance's patient compartment module.

The associated crash forces, in combination with the far greater mass of the ambulance, induced a sharp counterclockwise (CCW) rotation to the Jeep. It rotated CCW and was redirected back toward the northbound travel lane. It completed 315 degrees of total CCW rotation and slid to final rest within the northbound travel lane, facing east.

The ambulance maintained its forward trajectory after the initial impact and progressed farther off the right roadway edge. Its right rear tires began to furrow into the soft soil of the roadside and evidenced the ambulance's trajectory for 16.5 m (54 ft). The second crash event then occurred as the right aspect of the Ford's frontal plane impacted the steep roadside embankment that paralleled the roadway 3.5 m (11.5 ft) west of the roadway edge.

Figure 5: Left front tire mark evidence associated with the ambulance's travel path to Event 2.

As the Ford's right front bumper corner contacted the embankment, the right front axle position engaged the depression of the ditch and induced a sharp clockwise (CW) rotation. This was evidenced by the left front tire mark of the ambulance, which doglegged sharply right over the west white lane line and departed the west road edge perpendicular to the point of impact (**Figure 5**). The ambulance rotated CW and surpassed 90 degrees at 18 m (59 ft) south of the point of initial impact with the Jeep. An instability was created by the lateral drag force on the left side wheels, which rolled the bead of the outer left rear tire off the rim. The ambulance then tripped into a left side-leading rollover sequence (Event 3). This trip was evidenced by a deep gouge mark in the asphalt surface of the roadway from the outer left rear wheel rim, located 20.1 m (66 ft) south of the initial point of impact with the Jeep (5 m (16.4 ft) south of the Event 2 point of impact). The ambulance completed two quarter-turns during the uninterrupted rollover sequence before coming to final rest in the southbound lane, positioned on its top plane and facing north with its right side tires over the west roadway edge.

Post-Crash

Multiple calls were received by the local emergency response system from passersby who happened upon the crash scene. In response, local fire department, EMS, and law enforcement personnel were dispatched to the scene. First arriving emergency response personnel located the patient unresponsive in the overturned ambulance. He was removed immediately and transported by a ground ambulance to a local hospital. Ultimately, the patient succumbed to his injuries shortly after arrival at the hospital's emergency department.

The 25-year-old male EMS crewmember was located semi-responsive in the patient compartment of the overturned ambulance. He was removed from the vehicle and airlifted from the scene to a regional trauma center, where he was hospitalized for the treatment of a broken leg and multiple soft tissue injuries. The 21-year-old male driver was transported by a ground ambulance to a local hospital. He was later released within 24 hours after evaluation and treatment of minor soft tissue injuries.

The 22-year-old male driver was entrapped within the Jeep. Emergency response personnel removed him after an extended extrication process using hydraulic rescue tools. He was then airlifted to a regional trauma center, where he was hospitalized for treatment of his injuries. A local towing and recovery service arrived at the scene and transferred both the Jeep and the ambulance to the law enforcement agency's impound lot. The vehicles were still impounded at the time of the SCI inspection.

2005 FORD ECONOLINE 350 / MCCOY MILLER TYPE III AMBULANCE

Chassis Description

The 2005 Ford E350 chassis was identified by the Vehicle Identification Number (VIN): 1FDWE35P45Hxxxxxx. A placard confirmed that the vehicle conformed to all applicable Federal Motor Vehicle Safety Standards (FMVSS) in effect as of its date of manufacture. The chassis was a 351 cm (138 in) wheelbase, dual-rear wheel drive platform powered by a 6.0 liter, V-8 diesel engine linked to a 5-speed automatic transmission. At the time of the SCI inspection (**Figure 6**), the vehicle's electronic odometer reading was unknown. The vehicle manufacturer's recommended tire size and cold tire pressures remains unknown due to the inability to view a certification label. The Ford ambulance was equipped with LT225/75R16E tires at all visible axle locations. The front tires were Firestone Transforce H/T tires, while the outer left rear was a Uniroyal Laredo and the outer right rear was a Goodyear Wrangler. Due to the inspection restrictions imposed by the law enforcement agency, the SCI Investigator was not permitted to obtain tire pressure or tread depth measurements. However, it should be noted that both front tires and the outer left rear were visibly flat.

Figure 6: Front left oblique view of the 2005 Ford E350 / McCoy Miller Type III ambulance.

The multi-stage manufactured 2005 Ford E350 cutaway chassis was completed during secondary manufacturing with a Type III ambulance body. This Type III ambulance was configured with a forward cab and a rear patient compartment that was equipped for the treatment of medical emergencies in a mobile environment. Two seats were available for occupant seating within the cab. Both were forward-facing box-mounted seats with manual seat track and seat back recline adjustments, and featured 3-point lap and shoulder safety belt systems for manual restraint. Head restraints were integrated into the seat backs. A frontal air bag system provided supplemental restraint. Between the two seats and beneath the instrument panel's stereo and climate controls was a center console with an array of switches and communications equipment related to the ambulance's emergency response and operations activities.

Type III Patient Compartment Module

The McCoy Miller 142 SSB patient compartment of the Type III ambulance was configured with surrounding seating for EMS personnel and a centralized stretcher for the patient. Its exterior featured multiple storage compartments (three on both side planes) and three interior access doors (one right, two rear). The model 142 SSB designation referred to the 361 cm (142 in) exterior overall length of the patient compartment module, which had width and height dimensions of 229 cm (90 in) and 213 cm (84 in), respectively. The exterior compartments served for the storage of and curbside access to large emergency medical equipment and supplies, such as backboards, stair-chairs, trauma dressing kits, splints, oxygen cylinders, and roadside safety/vehicle equipment. The doublewide rear doors served for the loading and unloading of the stretcher, as well as entry/exit for the crew. There was also an occupant access door at the forward aspect of the right side.

The interior of the patient compartment module served as a mobile emergency room for the treatment of emergent medical conditions in a pre-hospital environment. It was configured for the seating of up to five crewmembers surrounding a centralized stretcher for the patient, with numerous wall-mounted cabinets, shelves, and countertops for the storage of medical equipment and supplies. Due to the amount of loose equipment, supplies, and other items within the patient compartment at the time of the SCI inspection, the interior of an exemplar patient compartment is depicted in **Figure 7**.

Figure 7: Interior of an exemplar patient compartment module.

The patient compartment module's frame was constructed of 2.5x5 cm (1x2 in) tubular aluminum stock aligned in a ladder-frame pattern. All joints along the sill and roof side rail were welded and covered with 0.3 cm (0.125 in) aluminum fascia and 0.6 in (0.25 in) aluminum trim. The exterior surfaces were 0.3 cm (0.125 in) aluminum sheeting that was tack-welded to the frame. The walls and ceiling contained fiberglass and closed-cell polymer insulation. A network of coated wires and hoses associated with the ambulance module's interior lighting, electrical, oxygen, and HVAC systems was intertwined within the insulation and throughout the walls. Interior surfaces of the patient compartment module and interior cabinetry were constructed of 1.2 cm (0.5 in) to 2.5 cm (1 in) painted plywood. Cabinets were equipped with 0.6 cm (0.25 in) plexi-glass panels inset within aluminum frames.

On the left side of the patient compartment were seven storage cabinets and two countertops, with an integrated seating position. The forward aspect, adjacent to the bulkhead, consisted of a large countertop, a switch panel with lighting and climate controls, wall-mounted radio communications equipment, and a large storage cabinet near the ceiling.

Aft of the large countertop was the "CPR seat", a position so-named as its location within the chest area of the patient (with respect to the stretcher) placed its occupant in an optimal location to perform cardiopulmonary resuscitation (CPR) on the patient if needed. The seat consisted of two cushions integrated into the wall-mounted cabinetry, with a wall-mounted lap belt available for the manual restraint of its occupant. Aft of the CPR seat was another countertop shelf with a cabinet beneath and a large storage cabinet mounted to the ceiling above. At the rear aspect of the left plane were four storage cabinets.

At the forward aspect of the patient compartment was a stack of storage cabinets, the cab/module pass-through, and the "Captain's Chair". The Captain's Chair provided seating for one occupant, and was so-named as its location near the communications equipment, the module's lighting and climate controls, and its proximity to the cab with rear-facing overview of the stretcher was frequently the location of the occupant providing administrative leadership for the crew.

The seat itself consisted of a box-mounted seat cushion and tall seat back with an integrated head restraint. The Captain's Chair was equipped with a lap belt for manual restraint. Immediately to the right of the Captain's Chair seat back was a pass-through to the cab, which enabled visual and verbal communication between the driver and crew. Adjacent to the right wall was a stack of four cabinets for the storage of medical equipment bags and linen. A Heating, Ventilation, and Air Conditioning (HVAC) system was located immediately beneath the ceiling.

The right occupant access door occupied the forward aspect of the right plane, adjacent to the bulkhead's stack of storage cabinets. Next to the door opening was a tubular handrail that contained the refuse bin and biohazard sharp objects container. This separated the door opening from the three-passenger bench seat affixed above the right rear axle position. The bench seat consisted of two cushions that were hinged to the wall to create a hidden storage compartment for oblong objects. The bench seat was equipped with wall-mounted lap belts for manual restraint of up to three occupants. Above the bench seat were two narrow storage cabinets affixed to the ceiling. The central area of the patient compartment module remained open and served as the location of the patient stretcher. Affixed to the floor was a forward antler bracket and a rear locking clamp to secure the stretcher in place. These components are described in detail in designated sections within this technical report.

Vehicle Weight/Payload

The placard concerning the vehicle's weight and payload information was placed by its manufacturer on the interior surface of the exterior compartment door located at the left front corner of the patient compartment, immediately aft of the left front door. Due to the inclusion of this component within the direct contact damage and deformation pattern, the compartment door was jammed shut. The SCI Investigator was therefore unable to obtain specific Gross Vehicle Weight Rating (GVWR), Gross Axle Weight Ratings (GAWR), and curb weight of the vehicle in order to determine usable payload and conclude if the ambulance was operating in excess of its available payload capacity at the time of the crash.

In the absence of exact placarded specifications, the values of an exemplar ambulance of a similar chassis/configuration was used to achieve an estimate of the desired calculations, and for comparison purposes, as follows: The GVWR of an exemplar 2001 Ford E350 Type III ambulance was 4,853 kg (10,700 lb), distributed as GAWRs of 2,086 kg (4,600 lb) front and 3,401 kg (7,500 lb) rear. Its overall curb weight was 4,078 kg (8,990 lb). Therefore, the calculated actual payload of the complete vehicle was 776 kg (1,710 lb). Based upon experience and knowledge of EMS equipment and typical ambulance configuration, the estimated combined weight of the EMS equipment and supplies on-board the involved ambulance at the time of the crash was a minimum of 408 kg (900 lb). The combined weight of the three occupants, based on average adult weights for the occupants' respective age segments, was estimated to be approximately 250 kg (550 lb). Based on these estimations and calculations, it was concluded that the laden ambulance was not operating in excess of its available payload capacity at the time of the crash.

Exterior Damage

Damage to the exterior of the ambulance from the multiple event crash was present on the front, left, and top planes of the vehicle. Associated with the Event 1 impact with the Jeep, direct contact damage began on the left plane, 90 cm (35.5 in) aft of the left front bumper corner on the left front fender (**Figure 8**) and extended rearward 286 cm (112.6 in) onto the patient compartment module. There was an isolated dent on the top aspect of the left front fender forward of the left front axle position, attributable to contact with the Jeep's left side mirror. The Event 1 engagement also included the left front axle position, which shortened the left wheelbase by 14 cm (5.5 in). Damage on the left plane continued from the left front fender onto the left front door of the cab, including minor body deformation with longitudinal abrasions. There was also black rubber transfer on the Ford's left front fender, attributable to the Jeep's left front tire. The forward aspect of the left front door was peeled rearward by the impact, exposing the door hinges. Direct contact damage extended onto the patient compartment module, with major deflection and full-height structural separation of the entire left front corner of the module. Within this damage pattern was minor lateral deformation. Across the 300 cm (118 in) Field-L, lateral crush included: C1 = 1 cm (0.5 in), C2 = 2 cm (1 in), C3 = 5 cm (2 in), C4 = 8 cm (3 in), C5 = 4 cm (1.5 in), and C6 = 2 cm (1 in). Maximum crush was located on the left front door of the ambulance near the handle (C4 location). No WinSMASH calculations could be performed for this (or any of the following) impact events because the ambulance's parameters exceeded the model's scope. The Collision Deformation Classification (CDC) assigned for the Event 1 damage pattern was 11LDAW2.

Figure 8: Left plane damage to the ambulance's cab (note front axle displacement).

Associated with the Event 1 impact and engagement was the separation of the patient compartment module's frame structure at the left front corner. This included the vertical corner beam, left roof side rail, and frontal roof header (**Figure 9**). The forward two compartments of the module's left plane were jammed shut as a result of the Event 1 impact damage; however, the rear compartment remained closed and operational. No damage or deformation was sustained by the diesel fuel filler nozzle located forward of the left rear axle or the 125 volt / 20 ampere shoreline electrical connection port located aft of the forward compartment door. Also within the damage pattern was buckling to the entire left plane of the patient compartment module, as well as distributed surface abrasions. The left side mirror had been fractured from its stalk and was not with the vehicle.

Figure 9: Separation of the roof structure, left roof side rail, and left front corner support of the module's frame.

Damage associated with the Event 2 embankment impact spanned the entire 175 cm (68.9 in) frontal end width. Initial engagement with the embankment began at the right front axle position, spreading left across the frontal plane as the ambulance had rotated CW. Damaged frontal components included the bumper beam and fascia. Using a 175 cm (68.9 in) Field-L, the crush measurements were obtained as follows: C1 = 10 cm (4 in), C2 = 5 cm (2 in), C3 = 2 cm (1.5 in), C4-C6 = 0 cm (0 in). The CDC assigned to the Event 2 damage pattern was 12FDLW1.

No measurable lateral or vertical crush was associated with the uninterrupted, two quarter-turn rollover. There were surface scratches to the left roof side rail, indicative of contact with the roadway's coarse asphalt surface. Based on the damage patterns, there was no indication of further structural damage associated with the rollover event to the patient compartment module. The CDC assigned to the Event 3 rollover damage pattern was 00TZDO1.

None of the vehicle's glazing was damaged during the crash sequence. The loading doors of the rear plane remained intact and operational. Although the SCI Investigator could not access the right occupant loading door, due to its isolation from the involved damaged planes it was presumed to have remained closed and operational post-crash. All compartment doors on the right plane also were presumed to have remained intact and operational.

Event Data Recorder

The Ford chassis was equipped with an Air bag Control Module (ACM) that served to command deployment of the vehicle's supplemental inflatable restraint systems. Despite the restrictions imposed by the law enforcement agency refusing the Investigator access to the vehicle's interior, the Ford chassis was not presently supported by the Bosch Crash Data Retrieval (CDR) tool. No data could be imaged from the Ford's ACM during the SCI inspection.

Interior Damage

At the time of the SCI inspection, no equipment or supplies had been permitted by the law enforcement agency to be removed from the vehicle, nor had any of the items within the interior allowed to have been touched. The law enforcement agency had not yet performed a forensic inspection of the vehicle, and was awaiting directive from the local District Attorney's office to complete their investigation and issue criminal charges. In lieu of these circumstances, the law enforcement agency did not permit the SCI Investigator entry into the vehicle's interior. Thus, the interior inspection of the ambulance's patient compartment and the stretcher was conducted using only a digital camera and monopod pole extended into the vehicle's interior from outside of the vehicle through the rear occupant loading doors of the patient compartment module.

Figure 10: Interior of the Ford ambulance's cab.

No access to the cab of the ambulance was achieved as a result of the jammed status of the left front door and the inability to open the right front door due to the ambulance's positioning tightly adjacent to the perimeter fence of the impound lot. Therefore, inspection of the Ford ambulance's cab was limited to photography through the right front glazing. There was no intrusion of frontal components into the Ford's cab visible during the SCI inspection; however, the rearward displacement of the front axles may have resulted in the minor vertical deflection of the toe pan for both front positions. The only visible remaining damage within the cab's interior consisted of the displacement of the switch panel cover within the center console. All vehicle glazing remained intact and was not damaged during the crash sequence or by occupant contact. **Figure 10** depicts the Ford's cab as viewed through the right front glazing.

Minor interior damage was sustained by the patient compartment as a result of the rollover crash. This consisted of the displacement of equipment and supplies, deflection of the bulkhead and cabinetry at the forward aspect of the patient compartment module, the separation of the handrail from its mount, and occupant contact to the forward and top plane components. Unsecured equipment within the patient compartment, as well as medical supplies stored within the cabinetry, were displaced during the crash sequence. Longitudinal forces associated with the first crash event induced forward movement to the sliding, clear polymer doors of the patient compartment's cabinetry. In lieu of there being no latches or stops to prevent said movement, the cabinet's clear polymer doors slid open during the crash sequence. Consequently, medical equipment and supplies stored within those respective cabinets were displaced and projected into the patient compartment's interior. Numerous loose items, equipment, and supplies were strewn throughout the patient compartment during the crash and as the vehicle came to final rest.

Figure 11: Cabinetry separation within the Ford ambulance's patient compartment.

Cabinetry separation occurred at the left and right aspects of the bulkhead, the result of induced buckling associated with the frontal Event 1 impact and subsequent Event 3 rollover sequence which separated the patient compartment's frame structure. Maximum separation appeared to not exceed 4 cm (1.5 in), and was not of significant magnitude to result in any integrity loss to the patient compartment. Cabinetry separation at the right aspect of the bulkhead, adjacent to the HVAC system, is depicted in **Figure 11**.

Figure 12: Contact evidence to the captain's chair seat back, interior surfaces, left side cabinetry, and ceiling of the Ford ambulance's patient compartment.

Contact evidence was identified within the patient compartment was attributable to EMS crewmember and patient occupant interaction with interior components. An area of loading and impression on the upper aspect of the captain's chair seat back was attributable to contact and loading from the stretcher occupant during the longitudinal Event 1 impact. There was also contact to surrounding components, including the bulkhead wall and adjacent cabinetry. The crewmember contacted the tubular handrail attached to the end of the bench seat, adjacent to the right side occupant access door. This contact separated the handrail from its mount. Lastly, a large pool of blood, attributed to the stretcher occupant, was located on the ceiling of the patient compartment. Contact evidence identified is depicted in **Figure 12**.

Manual Restraint Systems

The cab of the Ford chassis was equipped with manual restraint systems for both seating positions. Each was a 3-point lap and shoulder safety belt system that consisted of continuous loop webbing with a sliding latch plate, and was height-adjustable at its respective B-pillar-mounted D-ring anchor position. The driver's safety belt retracted onto an Emergency Locking Retractor (ELR), while the front right passenger's safety belt retracted onto an ELR/Automatic Locking Retractor (ALR). Due to the restrictions imposed on the SCI inspection, the cab's manual restraint systems were not physically examined and their status, including contact evidence and sustained damage (if any), remains unknown. Therefore, the investigation could not confirm manual restraint usage at the time of the crash by the driver based solely on the vehicle inspection.

The interior of the patient compartment module of the McCoy Miller ambulance was equipped with manual safety belt systems at all five seating positions. All were manual restraint systems that utilized a latchplate sewn to continuous loop webbing, which retracted onto ELRs mounted to the patient compartment wall. These belt systems displayed minor to no evidence of historical use. Although none of these systems could be physically examined for crash-related evidence during the inspection process, the injury outcome of the bench seat occupant and the statements of emergency services personnel whom responded to the crash scene were indicative that the occupant was unrestrained.

Supplemental Restraint Systems

The cab of the Ford chassis was equipped with a frontal air bag system that consisted of advanced dual-stage air bags available for the driver and front right passenger, mounted within the steering wheel hub and top instrument panel. The manufacturer of the vehicle has certified that the Ford's air bags were compliant to the advanced air bag portion of Federal Motor Vehicle Safety Standard (FMVSS) No. 208. Both air bags were installed by the original manufacturer and had not required any service/maintenance prior to the crash. The longitudinal crash pulse associated with the Event 1 impact resulted in the deployment of both frontal air bags (**Figure 13**). Due to the limitations imposed on the SCI inspection by the law enforcement agency and the Investigator's inability to access the interior of the cab, the air bags were not physically examined and their status, including contact evidence or damage (if any), remains unknown.

Figure 13: Deployed frontal air bags within the Ford ambulance's cab.

Patient Stretcher

The patient stretcher was a MX-PRO R3 Ambulance Cot that was manufactured by Stryker. It was constructed of a tubular aluminum frame with circumferential weld joints and steel hardware fasteners. The X-frame supporting the mattress platform featured manual raise/lower capabilities with seven height positions between a minimum of 34 cm (13.5 in) and a maximum of 95 cm (37.5 in). An exemplar Stryker MX-PRO R3 stretcher is depicted in **Figure 14**.

Figure 14: Exemplar Stryker MX-PRO R3 stretcher.

The mattress platform featured 2-73 degrees of positive backrest angular adjustment via a manually controlled gas-pressure cylinder. In a similar fashion, the leg portion featured 14 degrees of positive angular adjustment. Overall dimensions of the stretcher were 58 cm (23 in) wide and 205 cm (80.5 in) long. A placard declared that the load capacity limit of the stretcher was 295 kg (650 lb).

The Stryker stretcher was equipped with a multi-point harness system for manual restraint of its occupant (patient). This multi-point harness system included a lateral leg strap, lateral lap strap, and shoulder/chest harness, in which a pair of shoulder straps buckled into a chest strap. The safety belt webbing was continuous loop, and all straps included locking latch plates for length adjustment. Exact adjusted length of the straps at the time of the crash is unknown. During the photographic inspection of the ambulance's interior, the SCI Investigator noted that the lap and leg straps of the stretcher's harness system remained buckled. This evidence, in conjunction with visible contact damage on the bulkhead and ceiling of the patient compartment, suggested that the multi-point harness system was only partially utilized at the time of the crash. Specifically, the post-crash status of the straps and the injury outcome of the stretcher's occupant indicated that only the lateral leg, lap, and chest straps were used at the time of the crash. Neither the evidence in the patient compartment, nor the patient's apparent traumatic injuries, supported shoulder restraint strap usage.

Stretcher Anchoring System

The stretcher was secured in place within the patient compartment module via a Ferno-Washington, Inc. Model 175 Cot Fastener System. It was identified by the manufacturer's S/N: L784272. The system consisted of a forward antler bracket and rearward locking-clamp mechanism. The antler bracket cradled the forward portion (location of the patient's head area) of the stretcher's frame, while the vertically oriented locking mechanism clamped around a pin protruding from the stretcher's lower frame rail. Combined, these two components restricted the lateral and longitudinal movement of the stretcher.

The Event 1 impact induced significant longitudinal crash forces on the stretcher. Due to the combined mass of the stretcher and the patient, the stretcher's frame loaded the forward antler bracket. This restricted the stretcher's movement, and it remained locked in place. However, the lack of shoulder strap use to restrain the patient to the stretcher permitted unrestricted longitudinal movement of the patient. He ramped up the semi-inclined back of the stretcher and his body completely separated from the stretcher in response to the longitudinal forces.

During the rollover sequence, centrifugal and non-horizontal forces associated with the crash induced vertical and lateral movement to the stretcher (with respect to the patient compartment module's floor). Due to the location of the locking-clamp mechanism on the left aspect of the stretcher, the mass of the stretcher and aforementioned crash forces induced a positive moment of inertia about the longitudinal axis of the locking clamp.

The vertical orientation of the clamp translated an equivalent perpendicular normal force through the anchor pin to the stretcher's frame to restrict the lateral movement of the stretcher. As the rollover sequenced progressed, the magnitude of the inertial forces increased and surpassed the load capabilities of the locking mechanism. This disengaged the mechanism and allowed the stretcher's movement to become unrestricted as the locking pin separated from the clamp. Based on the statements of emergency response personnel, the stretcher ultimately came to rest partially on top of the patient and EMS crewmember in the overturned ambulance.

2005 FORD ECONOLINE 350 TYPE III AMBULANCE OCCUPANTS

Driver Demographics

Age / Sex:	21 years / Male
Height:	Unknown
Weight:	Unknown
Eyewear:	Unknown
Seat Type:	Box-mounted, forward facing, with integrated head restraint
Seat Track Position:	Full-rear
Manual Restraint Usage:	3-point lap and shoulder safety belt
Usage Source:	Official records
Air Bags:	Steering wheel hub-mounted frontal air bag deployed
Alcohol/Drug Data:	None
Egress from Vehicle:	Exited vehicle without assistance
Transport from Scene:	Ground ambulance to a local hospital
Medical Treatment:	Treated and released within a 24-hour period

Driver Injuries

Inj No.	Injury	AIS 2005/08	Injury Source	Confidence Level
1	Unknown soft tissue injuries	910000.1,9	Unknown	Unknown

Source: Official Records; Interview (Other: investigating law enforcement officer)

Driver Kinematics

The 21-year-old male driver was seated in the box-mounted seat. The seat track was adjusted to a full-rear track position, with the seat back slightly reclined. He was restrained by the manual 3-point lap and shoulder safety belt system, though his exact belt positioning is unknown. Restraint use was determined through a combination of the statements of law enforcement and emergency services personnel, as well as his injury outcome.

The driver initiated a slight forward and left lateral trajectory in response to his sharp braking and right steering input. His unsuccessful avoidance action also engaged the ELR, and his torso contacted and loaded the safety belt webbing. This kept the driver's body in position within the driver's seat. The driver then maintained his loading of the safety belt system in response to the Event 1 impact forces. His head and face probably contacted the deployed frontal air bag.

The Event 2 impact likely did not produce forces of enough significance to affect the driver's trajectory due to his maintenance of loading the seat belt in conjunction with the lateral forces associated with the vehicle's CW rotation. The driver remained restrained as the rollover sequence began.

As the vehicle came to rest, the driver remained within his position and restrained by the safety belt. Due to the position of the vehicle, he was suspended upside-down. The driver, having not sustained incapacitating injury in the crash, was able to slide his body vertically and unbuckle the latch plate. He then opened the right front door and crawled out of the vehicle. He then moved to the rear of the vehicle to assist his crewmember and the patient.

As emergency response personnel arrived, the driver was soon relieved of his efforts to assist in the removal of the patient compartment occupants and received emergency medical care. He was transported via ground ambulance to a local hospital, where he was treated and released within a 24-hour period.

Bench Seat Occupant Demographics

Age / Sex:	25 years / Male
Height:	Unknown
Weight:	Unknown
Eyewear:	Unknown
Seat Type:	Left-facing bench seat (non-adjustable)
Seat Track Position:	Not adjustable
Manual Restraint Usage:	None
Usage Source:	Vehicle Inspection; Official Records
Air Bags:	None available
Alcohol/Drug Data:	None
Egress from Vehicle:	Removed from vehicle due to perceived injuries
Transport from Scene:	Airlifted to a regional trauma center
Medical Treatment:	Admitted to the trauma center for treatment for an unknown length of time

Bench Seat Occupant Injuries

Inj No.	Injury	AIS 2005/08	Injury Source	Confidence Level
1	Fractured leg, NFS	852002.2,9	Tubular handrail	Possible

Source: Official Records; Interview (Other: investigating law enforcement officer)

Bench Seat Occupant Kinematics

The 25-year-old male EMS crewmember was seated on the left-facing bench seat. He did not utilize the available lap belt system attached to the patient compartment wall for manual restraint. The EMS crewmember was engaged in obtaining vital signs and completing documentation for patient care. The EMS crewmember initiated a right lateral trajectory (with respect to his left-facing orientation) in response to the longitudinal forces associated with the Event 1 impact.

Due to the smooth vinyl surface of the bench seat's cushion and the crewmember's lack of manual restraint usage, his body translated along the bench seat. His right flank and leg contacted and loaded the tubular handrail. This contact possibly resulted in the leg fracture. As the vehicle entered the CW rotation and initiated the rollover sequence, the EMS crewmember initiated a forward trajectory (with respect to his left-facing orientation) and separated from the bench seat. His legs possibly contacted the stretcher, and his head and shoulders probably contacted left wall cabinetry.

The unrestrained EMS crewmember came to rest on the ceiling of the overturned vehicle. Displaced equipment, supplies, and the stretcher likely contacted the bench seat occupant. Post-crash, he was removed from the patient compartment module of the vehicle due to his perceived level of injuries by emergency response personnel. He was transported via helicopter to a regional trauma center for evaluation and treatment. The duration of his stay and extent of his injuries remains unknown.

Stretcher Occupant Demographics

Age / Sex:	59 years / Male
Height:	Unknown
Weight:	Unknown
Eyewear:	Unknown
Seat Type:	Other seat type (specify: EMS stretcher)
Seat Track Position:	Not adjustable
Manual Restraint Usage:	Partial use of multi-point harness system (lateral straps only)
Usage Source:	Vehicle inspection; Official Records
Air Bags:	None available
Alcohol/Drug Data:	None
Egress from Vehicle:	Removed from vehicle by emergency response personnel
Transport from Scene:	Ground ambulance to a local hospital
Medical Treatment:	Pronounced deceased after arrival at emergency department

Stretcher Occupant Injuries

Inj No.	Injury	AIS 2005/08	Injury Source	Confidence Level
N/A	Unknown	N/A	N/A	N/A

Source: Official Records; Interview (Other: investigating law enforcement officer)

Stretcher Occupant Kinematics

The 59-year-old male patient was positioned semi-Fowler's (anatomical sitting position of comfort with torso slightly reclined and legs extended forward) on the Stryker stretcher. He was partially restrained by the multi-strap harness system, utilizing only the lateral chest, waist, and leg straps. The partial restraint usage was determined by a combination of the statements of the ambulance agency's personnel, the post-crash observations of on-scene emergency response personnel, and occupant contact evidence identified during the SCI vehicle inspection.

The male patient initiated a rearward trajectory (with respect to his rear-facing orientation) in response to the driver's braking avoidance input and the longitudinal Event 1 and Event 2 crash forces. His body loaded the cushion of the stretcher and translated forward. Despite the use of the lateral restraint straps, the lack of longitudinal restraint allowed the patient's body to ramp up the semi-inclined back of the stretcher and separate completely from it. His head and shoulders then contacted and loaded the captain's chair, resulting in the contact evidence previously identified and likely inducing soft tissue and other head injuries.

As the ambulance progressed through the crash sequence, the patient contacted the bulkhead wall. He then initiated a left lateral trajectory in response to the CW rotational and rollover forces. His right flank and extremities would have contacted the left wall cabinetry, inducing further injury. The stretcher occupant was also probably contacted by numerous items, including displaced medical equipment and supplies.

The stretcher occupant came to rest on the ceiling of the patient compartment in the overturned ambulance. The stretcher, which disengaged from the locking clamp mechanism during the crash sequence, probably landed on top of him. This may have exacerbated and/or induced further injury. Soft tissue injuries bled profusely, resulting in the large pool of blood on the ceiling. The patient entered traumatic hypovolemic shock, a state in which vital body organs begin to fail due to excessive blood loss, and ultimately suffered cardiac arrest. Emergency response personnel transported the male patient via a ground ambulance to a local hospital. They attempted to resuscitate him, but he ultimately succumbed to his injuries and was pronounced deceased at the local hospital.

1999 JEEP CHEROKEE SPORT

Description

The 1999 Jeep Cherokee was equipped with the Sport trim package and was identified by the VIN: 1J4FF68S4XLxxxxxx. The vehicle's date of manufacture and its odometer reading remain unknown. The four-wheel drive, 4-door sport utility vehicle had a 258 cm (101.4 in) wheelbase. It was powered by a 4.0 liter, V-6 engine that was linked to a 5-speed automatic transmission. No physical inspection of the Jeep was permitted by the law enforcement agency, but the SCI Investigator was allowed to take a few photographs. A left front oblique view of the Jeep is depicted in (**Figure 15**). The Jeep's GVWR/GAWR, odometer reading, and tire size/inflation pressure recommendation data remains unknown. The interior of the Jeep was configured for the seating of five occupants. Safety features included 3-point lap and shoulder safety belts for the four outboard positions, with a lap belt for the second row, center position.

Figure 15: Left front oblique view of the 1999 Jeep.

Exterior Damage

The front and left planes of the Jeep sustained moderate to severe damage as a result of the crash. An impression from the left corner of the ambulance's patient compartment was visible on the far left aspect of the Jeep's hood. The left front axle of the Jeep was nearly separated from the vehicle, indicative of severe engagement with the left front axle of the Ford ambulance. Direct damage extended down the left plane of the Jeep to the left rear door. Based on the images of the Jeep, the CDC assigned to the Event 1 damage pattern was 12FLEE9.

Occupant Data

The Jeep was driven by a 22-year-old male. His restraint status remains unknown. Official records indicate that the male driver was operating the Jeep under the influence of controlled substance(s). He sustained incapacitating injuries in the crash and had to be extricated from the vehicle by emergency response personnel. A helicopter airlifted the 22-year-old male to a regional trauma center, where he was treated for his injuries. The duration of his stay at the trauma center and the extent of his injuries remains unknown.

CRASH DIAGRAM